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THE INFLUENCE OF US ARMY BASIC INITIAL TRAINING ON THE MUSCULAR--ETC(U)
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THE INFLUENCE OF US ARMY BASIC INITIAL ENTRY TRAINING
ON THE MUSCULAR STRENGTH OF MEN AND WOMEN

US ARMY RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE

Natick, MA 01760

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Abstract

The influence of US Army Basic Initial Entry Training on the maximum voluntary isometric strength (MVIS) and anthropometric parameters of men and women was investigated. Significant increases in weight and lean body mass (LBM) and decreases in percent body fat were found for both sexes during training. Significant increases in the MVIS of the upper torso (UT), leg extensors (LE) and trunk extensors (TE) were also found for both sexes. Females and males improved about the same amount on the LE (12.4% and 9.7% respectively) but females improved significantly more than males on the UT (9.3% and 4.2% respectively) and TE (15.9% and 8.1% respectively). The greater gains in the females were presumably due to their lower initial strength levels and the consequently greater relative training stimulus. When strength was expressed relative to LBM, both sexes were able to exert similar amounts of strength on the LE and TE suggesting that differences in strength between the sexes may primarily be a function of muscle mass.

Key words: isometric strength, training, anthropometry, male-female comparisons

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The question of how women respond to physical training when compared to their male counterparts is of considerable importance in the light of the increased utilization of women in jobs requiring substantial physical effort. This is especially true in the military service where women are now frequently entering occupations formerly held exclusively by men. Recently, the US Army began placing men and women into the same training units for their basic initial entry training. This policy offered the unique opportunity to study the physiological responses of both sexes to a similar physical training program.

Studies can be found that have assessed the aerobic capabilities of men and women training similarly in a general conditioning program (2,12,24). However, with the exception of studies that have looked at specific types of weight training programs (25,26) very little attention has been paid to muscular strength. Vogel, Ramos and Patton (24) did previously examine changes in strength consequent to basic training but this study was cross sectional rather than longitudinal.

Objective measures of human isometric muscular strength in the intact subject can be obtained provided certain methodological criteria are met, namely that the instructions given the subject are standardized (3,5,14,15), certain biomechanical factors are taken into consideration (11), and the tests are acceptably reliable (13). A device for the measurement of three major muscle groups was developed taking these factors into account and has been described in detail in another publication (11). The present investigation utilized this device to assess the influence of basic training on the maximum voluntary isometric strength (MVIS) of males and females.

Methods

The sample consisted of 948 males and 496 females reporting for basic training at a large US Army training center. Subjects were briefed in large groups and informed consent was obtained from all those choosing to volunteer. This ranged from 95% to 98% of those briefed. Because of scheduling conflicts, discharges, injuries, illnesses, equipment failures and voluntarily declining further participation, the final sample consisted of varying numbers of subjects for the different parameters. Only subjects with complete data on a particular parameter were included in the analysis of that parameter.

A pretest/post-test design was utilized. The pretest was administered during the first week of the seven week basic training cycle and the post-test was performed during the sixth or seventh week. Pretests and post-tests were identical. The training program is described in three publications (6,22,23) and consists primarily of calisthenic, strengthening, running and marching activities. All exercises were of progressively increasing exercise intensity. Calisthenics and strengthening activities were performed about 1 hr each day, 5 to 6 days a week beginning with 5 repetitions the first day and progressing to about 12 repetitions by the end of training. These included warm up activities as well as various exercise series (rifle drills, grass drills, log exercises, team contests) as described in the Drill Sergeant's Guide (6). Additionally, running was performed beginning with 1/4 mile, progressing to 1 1/2 mile in less than 11 minutes by the end of training. Extensive marching and other military activities were included.

In both the pretest and post-test weight (Wt) and skinfold thicknesses were obtained; height (Ht) was measured only during the pretest. Wt was obtained from a digital scale and Ht from a fabricated free standing device. Subjects' Wt and Ht were taken in their stocking feet wearing a T-shirt and standard issue

fatigue pants. Skinfold measurements were taken with Harpendin calipers at four sites: biceps, triceps, suprailiac and subscapular. The equations of Durnin and Wormsley (7) were used to obtain an estimate of percent body fat (% BF) from which lean body mass (LBM) was calculated.

Insert Figures 1, 2 and 3 about here

The MVIS of three major muscle groups was evaluated with a device constructed in this laboratory (11). These muscle groups were the upper torso (UT), leg extensors (LE) and trunk extensors (TE). The standardized positions for these tests are shown in Figures 1, 2 and 3, respectively. For the UT the elbow was set at an angle of 90° with the upper arm parallel to the floor. For the LE, the angle of the knee was set to 90° and for the TE, the strap around the subject's torso was positioned two inches inferior to the acromion process. When a subject arrived for testing a technician recited a standard set of instructions while the subject was positioned in the device. The subject was instructed where to exert the force at each of the three stations on the device as well as the proper posture during the force exertion. The subject was asked to build up to his maximal strength as rapidly as possible without jerking and hold it until told to relax. The length of the contractions was three to five seconds. In all three test positions a vector component of the force exerted by the subject was transmitted along a cable to a cable tensiometer (Pacific Scientific Co., Anaheim, CA). A maximum force indicator retained the peak exerted force and this force was recorded. If a subject produced a jerking motion during any phase of a contraction that contraction was repeated. At least three trials were given to each subject on each muscle group in a single session. Thirty seconds of rest

were allowed between each trial. If one of these trials was not within 10% of the other two, that trial was repeated up to a maximum of five trials. The mean of the three highest trials was taken as the criterion strength score.

In order to estimate reliability, a subsample of eight males and eight females were tested on two consecutive days. Procedures utilized on both days were essentially identical to those described above.

Results

Descriptive statistics on the anthropometric parameters are summarized in Table I. Training resulted in statistically significant increases in Wt and LBM and a decrease in %BF for both males and females (paired T-test, $p < .05$).

Reliability of the strength parameters was estimated using intraclass correlation techniques (20). A repeated measures ANOVA (8) was performed on the six trials of each muscle group (three trials on each of Day 1 and Day 2) for the 16 individuals in the subsample. None of the F-values were statistically significant indicating the scores did not change over trials or days. Reliability estimates for the UT, LE and TE were 0.97, 0.92 and 0.83, respectively. In all three cases a larger share of the variance in MVIS was due to day-to-day rather than to trial-to-trial variations.

Insert Figures 4, 5 and 6 about here

Histograms showing the distribution of strength scores for the males and females before and after basic training are shown in Figures 4, 5 and 6. In all cases the distribution has shifted to the right after training indicating that both males and females generally improved their MVIS. Table II presents some descriptive statistics for the three muscle groups. A two-way ANOVA was used

to compare males and females as independent groups and pre and post training as repeated measures for each of the strength parameters individually (8). The main effects of gender and training were significant in all cases ($p < .05$). The interaction effect was significant for both the UT ($F(1,1090) = 4.22, p < .05$) and the TE ($F(1,1108) = 9.29, p < .05$) but was not significant for the LE ($F(1,1082) = 1.59, p > .05$).

When strength was expressed relative to weight and lean body mass (Table III) differences between males and females were considerably reduced.

Discussion

For all muscle groups males were significantly stronger than females both before and after training although both groups improved as a result of training. The increases in strength for both men and women were smaller than those found in specific weight training studies (4,25,26) since the training program used here was of a much more general nature. The reliability of the TE was low, however, mandating some caution in interpretation of these values. Laubach (16) reviewed nine reports comparing the absolute muscle strength of men and women. In combining the data from these studies he found the following: the upper extremity strength of females was approximately 56% that of men, lower extremity strength 72% that of men and trunk strength 64% that of men. These values in the present study before basic training were 57%, 65% and 66%, respectively. After basic training these values changed to 60%, 67% and 72%, respectively. Thus, basic training brought the strength of the females closer to that of the males.

Muller (18) has postulated that there is an almost exponential rise in strength with training. That is, training causes strength to rise rapidly at first then increase much less rapidly up to a point where no further increases in strength are possible. This latter point is called the limiting strength. Females began training at a lower level of strength than the males on the UT and TE. However, the amount of improvement for the females was almost double that of the males. This suggests that the females were provided with a greater relative training stimulus and were consequently able to improve their strength to a greater extent.

On the other hand, even though females started at lower levels of strength on the LE, they improved about the same amount as the males. Wilmore (25) also found that males and females improved similarly on the legs and with one exception, females generally showed more improvement on the upper body parameters. He suggested that males and females perform similar activities with the legs but females tend to use the upper body less and consequently have a greater potential for development. In another study (26), a circuit weight training program resulted in greater improvements for females when compared to males, on both leg and upper body measures, although the authors suggested that males may have been working at a lower intensity than the females.

Because of structural (1) and hormonal (10,19,21) differences between the sexes, it is doubtful that females will ever reach the same level of absolute strength as the males. However, there seems to be some support for the idea that the relative strength of men and women are roughly comparable. In the present study when strength was expressed relative to LBM, the resultant ratios were very similar for men and women on the LE and TE. On the basis of this ratio and using a more direct measure of LBM, Wilmore (25) actually found that females surpassed males on leg strength. Ikai and Funkunaga (9) found that strength per cross sectional area of muscle tissue was about the same for males and females although in their oldest age group (about 20 years old) an 8% difference still existed. Thus, differences in strength between the sexes may primarily reflect differences in muscle mass. However, on the upper body the present study and a previous one (25) found males and females widely separate in terms of their relative strength.

It can be concluded that females can improve their strength to a great extent in basic training. Beyond basic training, specific types of training

programs could be implemented to improve the strength of females for specific tasks. Such an approach was used by Murphy and Nemmers (18) who designed a training program to equip sedentary female soldiers with the physical capacity to successfully load and fire howitzer cannons.

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Table I. Anthropometric Parameters for Males and Females (Values represent means \pm S.D.)

	Males (N = 769)		Females (N = 393)	
	Pretest	Post-test	Pretest	Post-test
AGE (yr)	19.8 \pm 2.7		20.7 \pm 3.2	
Ht (cm)	174.3 \pm 6.6		162.5 \pm 6.8	
Wt (kg)	70.9 \pm 10.6	71.7 \pm 8.8	59.1 \pm 7.1	61.3 \pm 6.7
% BF	16.3 \pm 5.1	14.5 \pm 3.8	28.0 \pm 4.7	26.5 \pm 3.7
LBM (kg)	59.3 \pm 6.8	61.1 \pm 6.4	42.4 \pm 4.3	44.9 \pm 4.5

Table II. Descriptive Statistics for the Muscular Strength Parameters (R-Value represents the Spearman product-moment correlation between the pretest and post-test values)

		MALES		FEMALES	
		PRETEST	POST-TEST	PRETEST	POST-TEST
UT (MALE N=733 FEMALE N=359)	MEAN (KG)	97.8	102.1	55.3	61.0
	SD	18.2	16.2	11.8	9.6
	% Δ		4.2		9.3
	R-VALUE		0.62		0.81
LE (MALE N=737 FEMALE N=348)	MEAN (KG)	143.2	158.2	93.4	106.6
	SD	38.4	41.1	30.0	31.1
	% Δ		9.7		12.4
	R-VALUE		0.71		0.76
TE (MALE N=750 FEMALE N=360)	MEAN (KG)	72.6	79.0	47.6	56.6
	SD	18.2	16.5	12.7	10.6
	% Δ		8.1		15.9
	R-VALUE		0.58		0.67

Table III. Force/Weight (F/W/T) and Force/Lean Body Mass (F/LBM) Ratios for Males and Females (values represent means \pm S.D.)

	F/W/T (kg/kg)			F/LBM (kg/kg)			
	Males	Females	Ratio	Males	Females	Ratio	
	F/M						
Pretest	UT	1.39 \pm 0.23	0.94 \pm 0.21	.68	1.66 \pm 0.25	1.31 \pm 0.27	.79
	LE	2.04 \pm 0.53	1.59 \pm 0.50	.78	2.43 \pm 0.61	2.20 \pm 0.68	.91
	TE	1.04 \pm 0.26	0.81 \pm 0.22	.79	1.24 \pm 0.30	1.13 \pm 0.29	.91
Post-test	UT	1.43 \pm 0.18	1.00 \pm 0.16	.70	1.67 \pm 0.20	1.36 \pm 0.20	.82
	LE	2.22 \pm 0.54	1.75 \pm 0.50	.79	2.59 \pm 0.62	2.38 \pm 0.68	.92
	TE	1.11 \pm 0.22	0.93 \pm 0.18	.84	1.29 \pm 0.26	1.27 \pm 0.24	.98

Legends for Illustrations

Figure 1. Subject positioning for UT stength measurements.

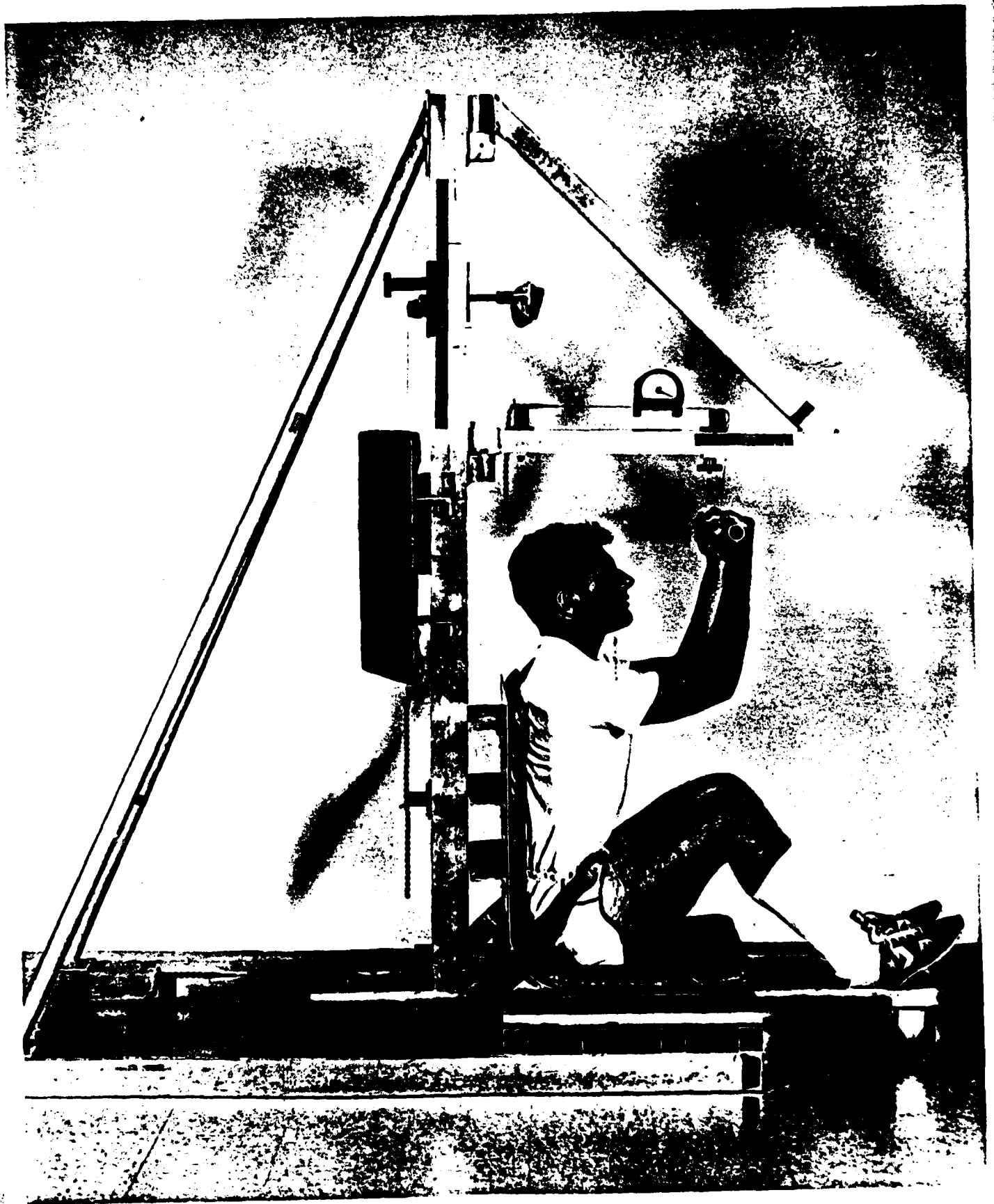
Figure 2. Subject positioning for LE strength measurement.

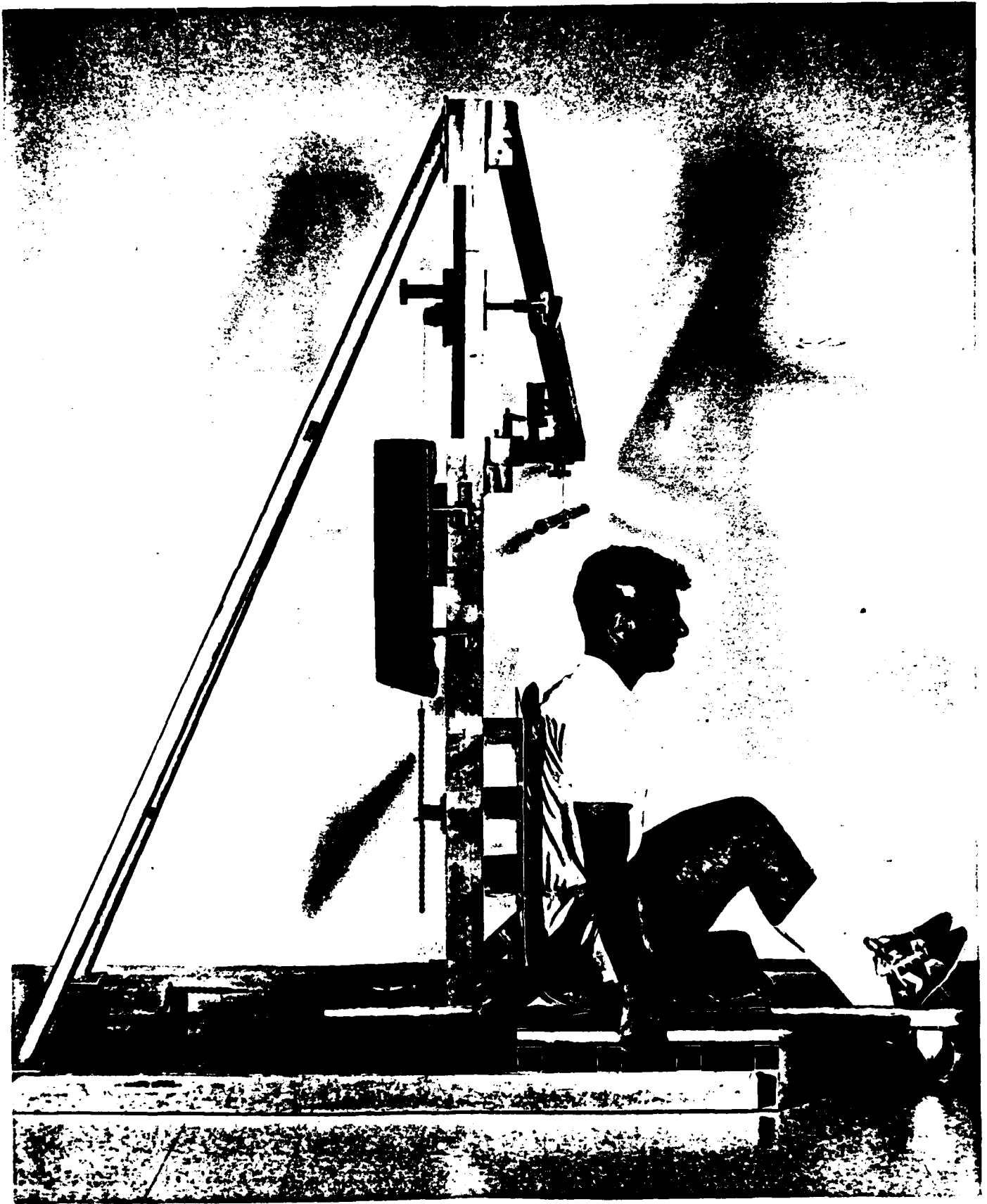
Figure 3. Subject positioning for TE strength measurements.

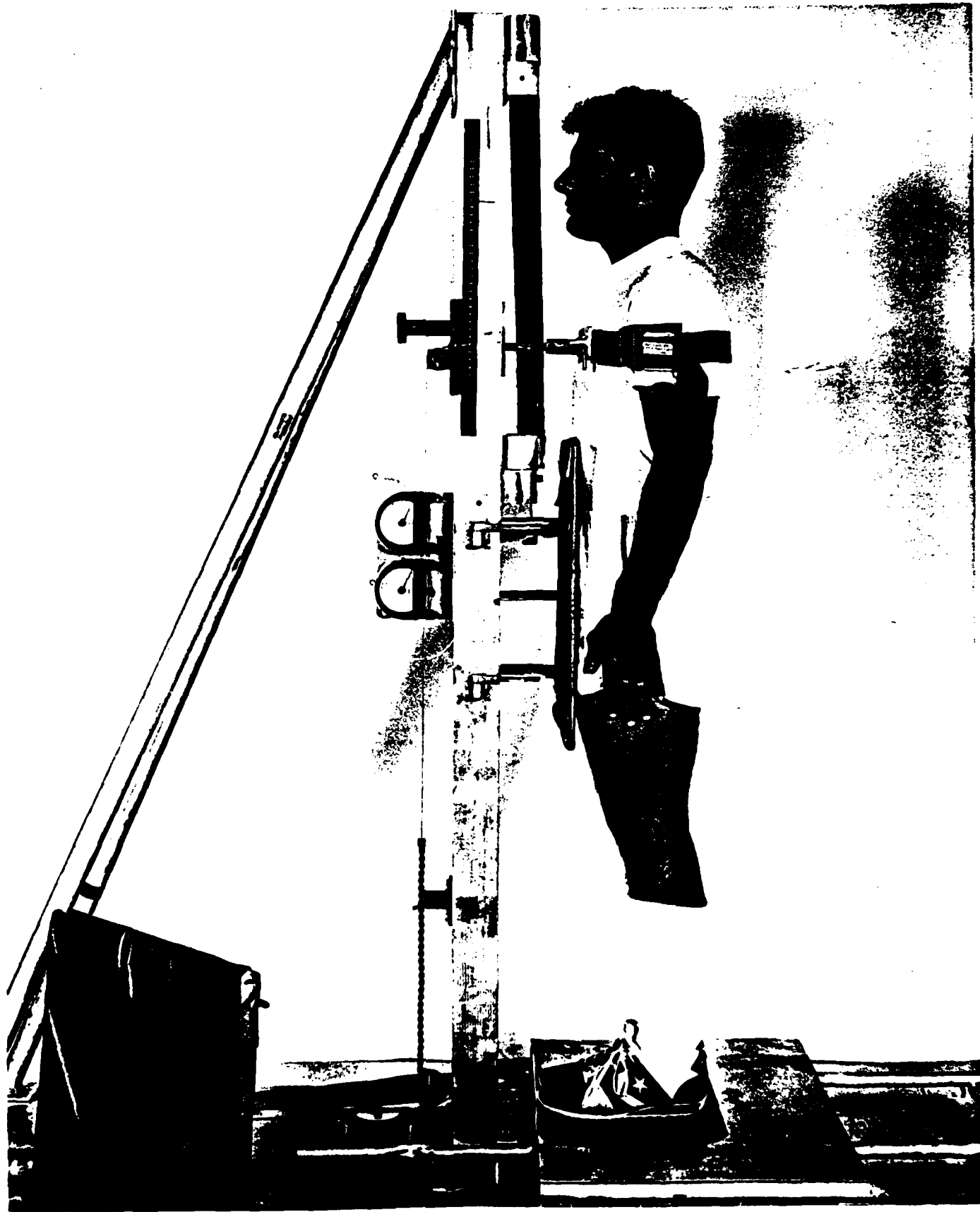
Figure 4. Distribution of UT strength scores.

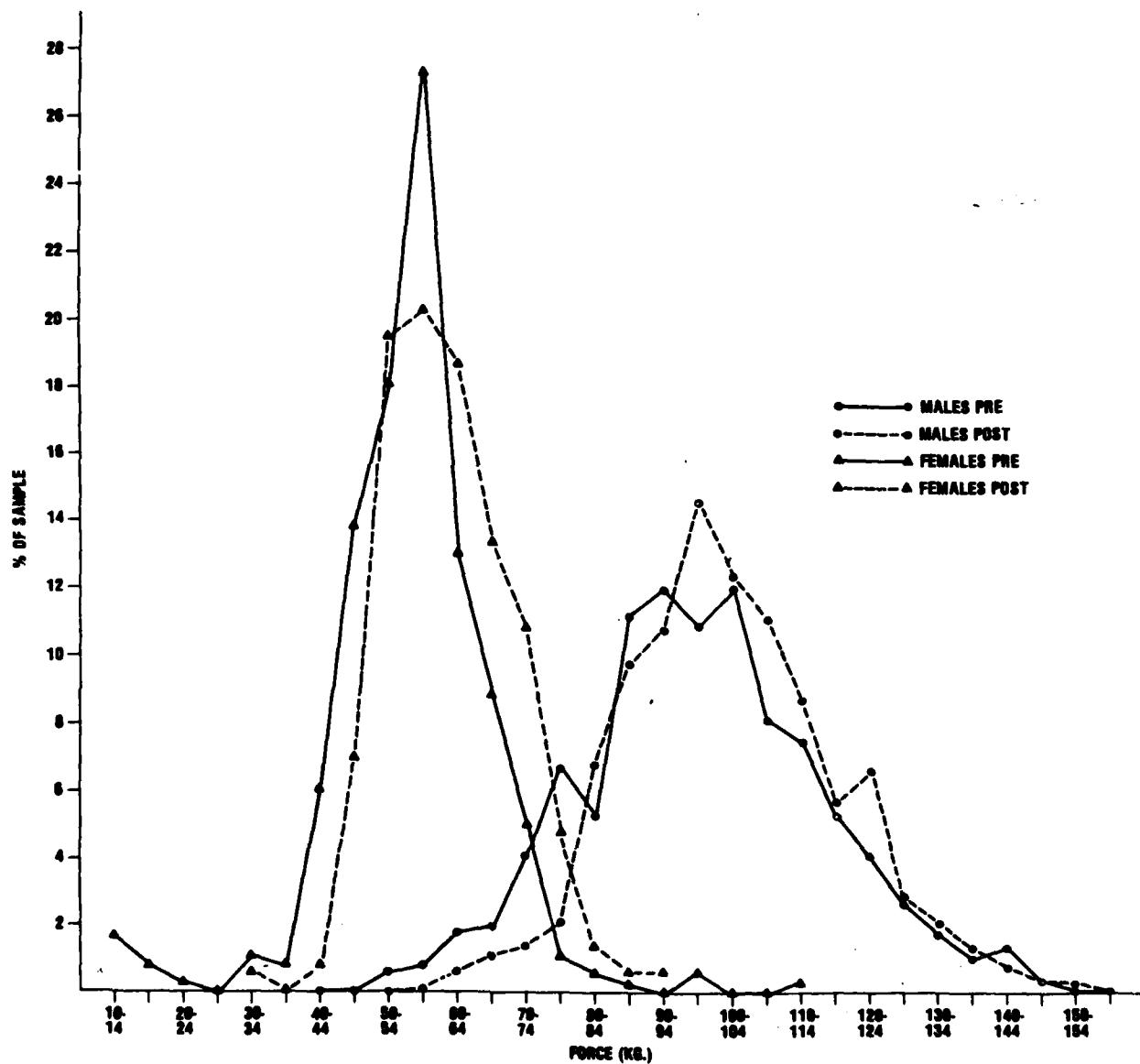
Figure 5. Distribution of LE strength scores.

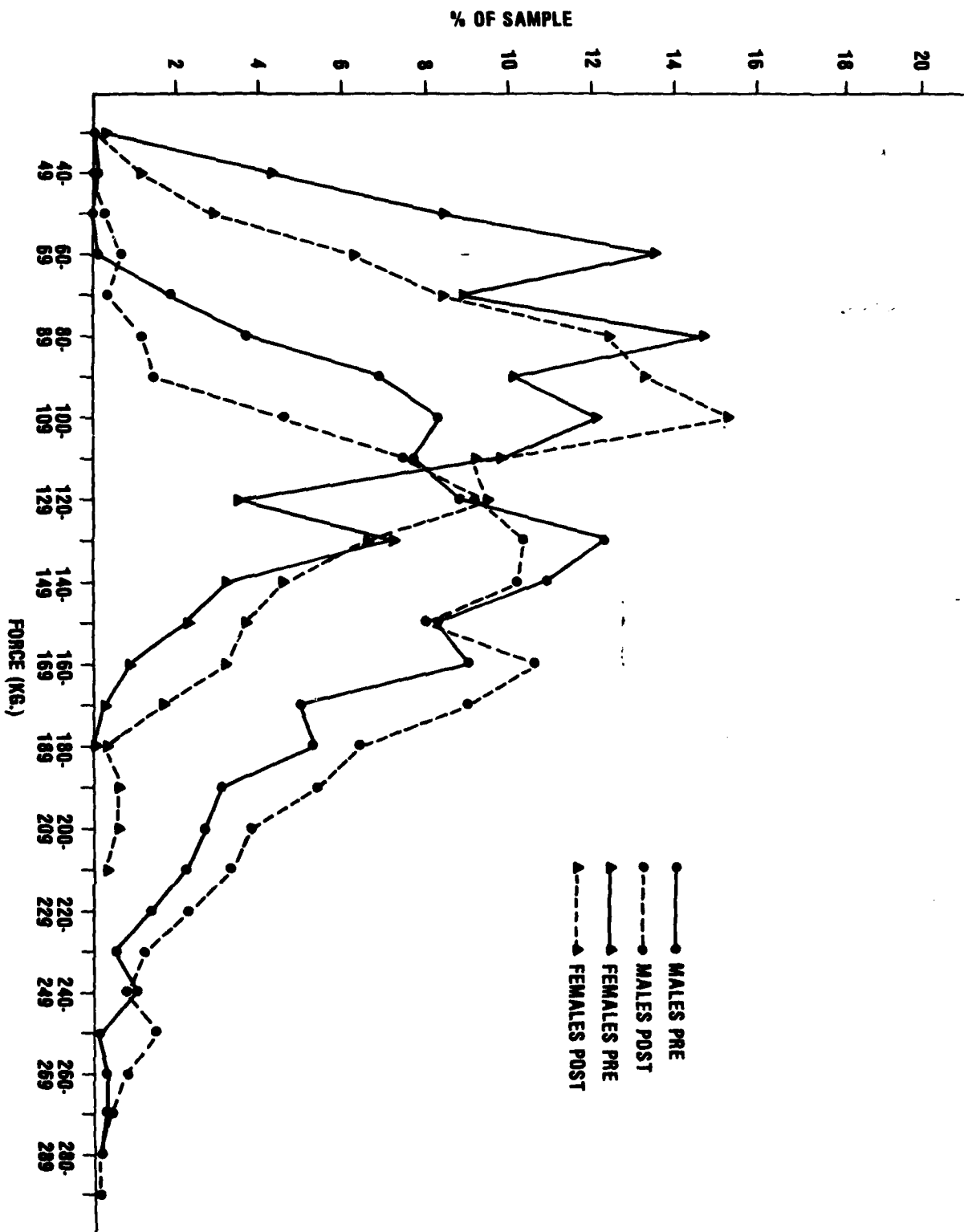
Figure 6. Distribution of TE strength scores.

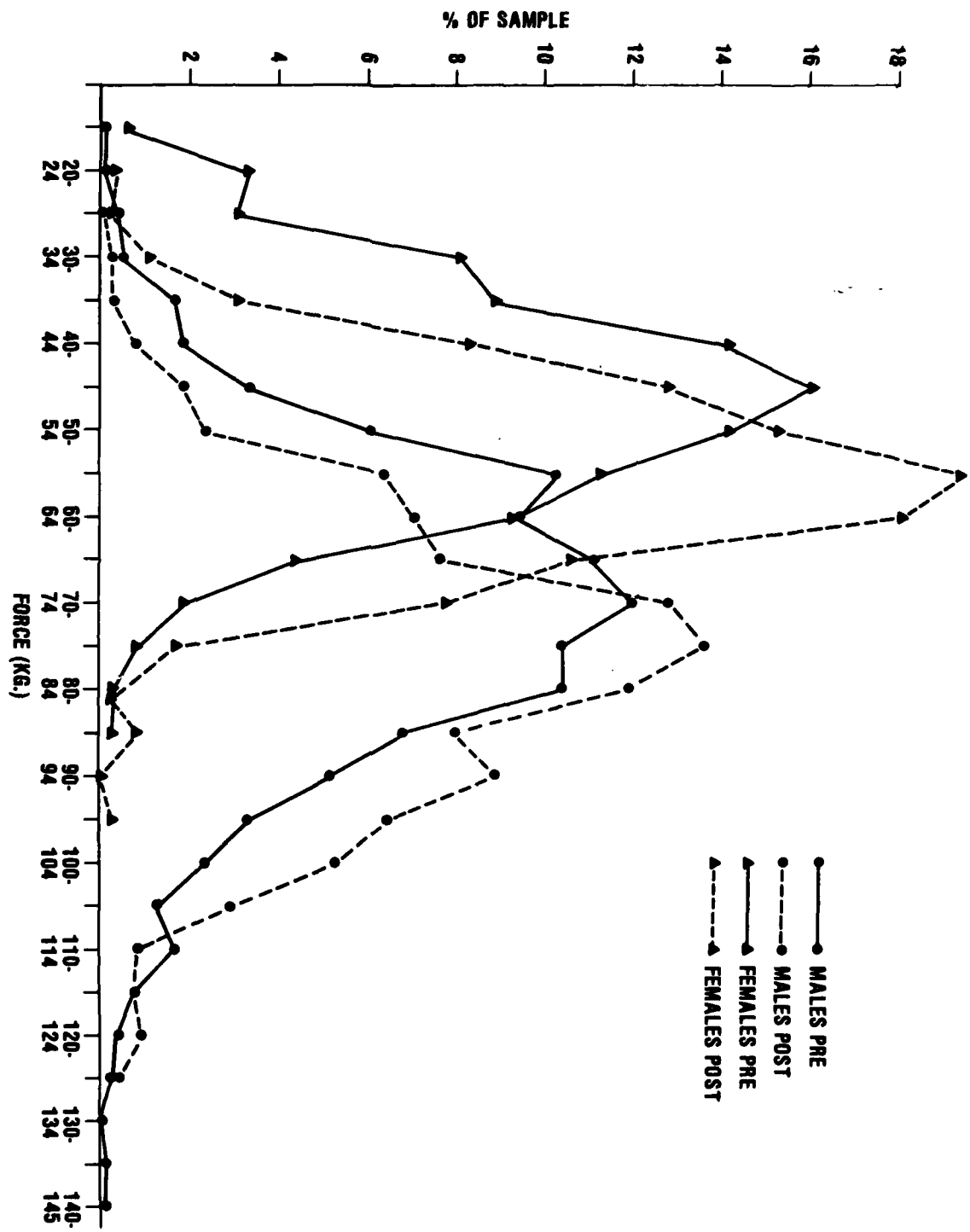












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Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.